Assessment and Optimization of Medical Risks Using the Integrated Medical Model

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Objective

Develop an evidence-based, probabilistic risk forecasting model that can help guide mission planning, requirements development, and align science with engineering technology development.

Scope

- The IMM forecasts medical outcomes for in-flight operations only and medical impacts to the mission
- Optimizes in-flight mass, volume, power for a given crew and mission profile
- Does not assess long-term or chronic medical impacts of crew health

Approach

- Uses ISS resources as medical capabilities.
- Evidence based clinical research methods
- Probabilistic risk assessment techniques while collaborating with other NASA centers.

Formulating the Conceptual Model of IMM

1. HRP Risk
The inability to treat an ill or injured crew member

2. Problem
The inability to adequately reduce crew health risks via an in-flight medical system within operational constraints

3. Objectives

- Enable evidence-based, risk-informed decisions by the HRP community in the context of crew profiles and mission constraints
- Enable evidence-based, risk informed decisions by the flight surgeon community in the context of crew and mission profiles
- Provide comparative risk assessments among crew and mission profiles
- Identify the medical equipment, pharmaceuticals, and consumables that most influence the decrease of mission health risks
- Optimize the allocation of medical resources for a given mass, volume, power, cost and level of acceptable risk
- Communicate comparative risk assessments effectively with operational programs

4. Fundamental Questions

For a specified mission scenario:

- What medical conditions can be expected to occur?
- How many occurrences of these medical conditions can be expected?
- What medical conditions can be expected to have the most impact on crew health?
- What medical resources are most likely to be utilized?
- What is the probability of loss of crew life or evacuation due to medical events?
- What is the expected crew functional impairment?
- What are the optimal medical resources to minimize crew functional impairment and the probability of evacuation or loss of crew life?

5. Outputs
A comparative analysis of missions, forecasts of medical events, estimates of risk to crew health and projections of resource usage.

6. Inputs
Consists of mission specific parameters and crew profiles.

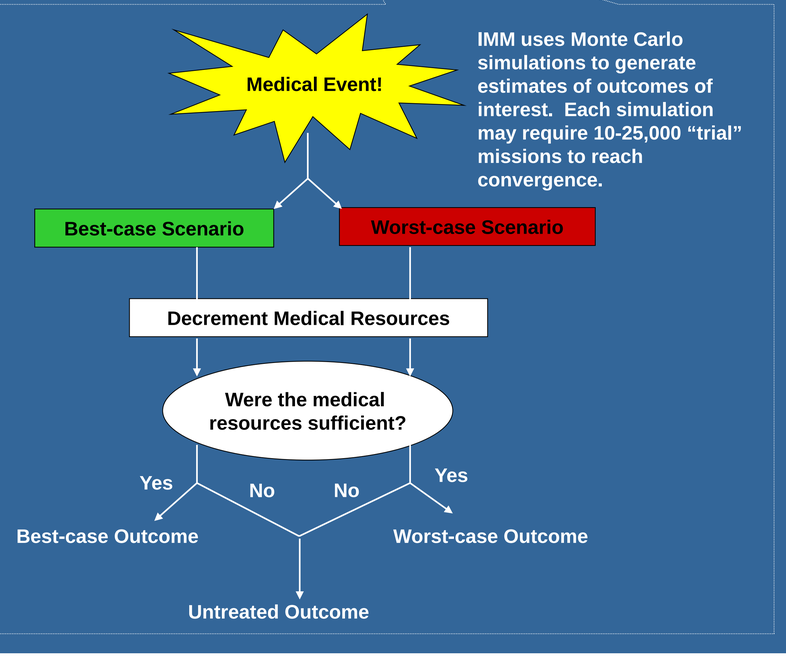
INPUTS

- Medical Conditions & Incidence Data
- Crew Profile
- Mission Profile & Constraints
- Potential Crew Functional Impairments
- Potential Mission End States
- In-flight Medical Resources

IMM

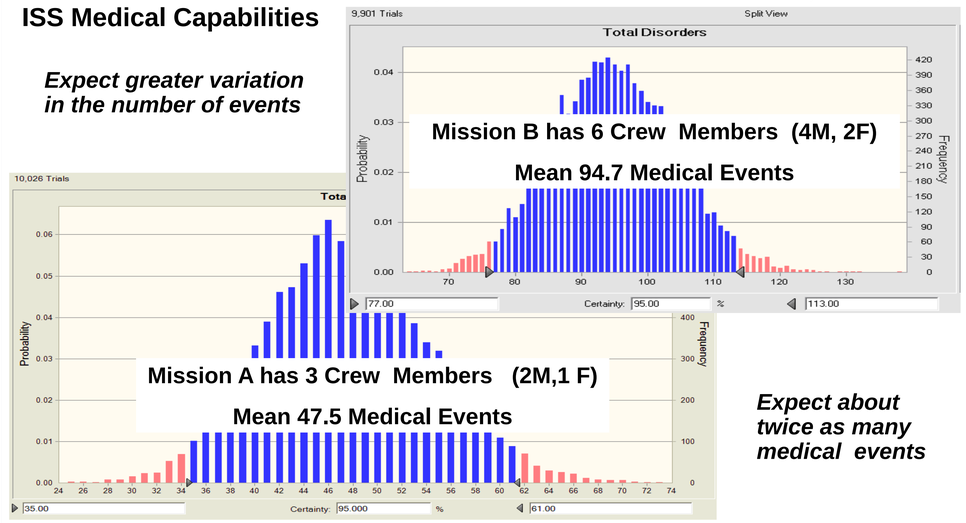
OUTPUT of Distributions

- Medical Condition Occurrences
- Crew Impairment
- Clinical End States
- Mission End States
- Resource Utilization
- Optimized Medical System



Example: Compare the number and type of medical events for similar missions but with different crews; Mission duration is 6 months, 3 EVA's, ISS Medical Capabilities

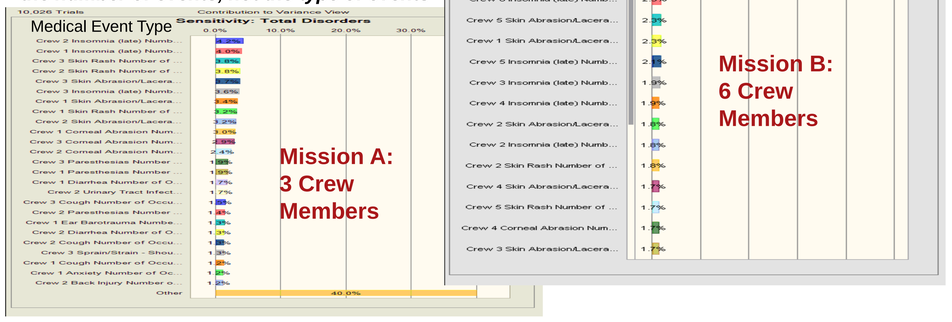
Expect greater variation in the number of events



Expect about twice as many medical events

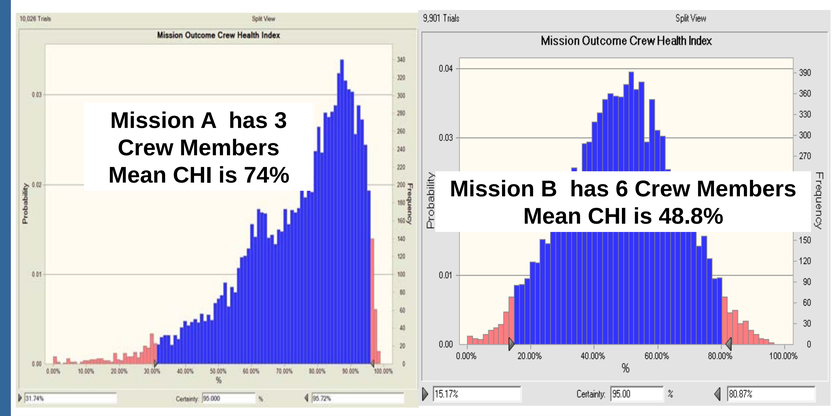
Sensitivity Analysis – Which of the 80+ medical conditions represented in IMM influence crew health most?

Increasing the size of the crew only changes the number of events, not the type of events



Comparative Analysis - Crew Health Index (CHI)

Doubling crew size without adjusting medical capabilities results in a 34% decrease in CHI, representing a relative increase in crew health risk comparing Mission A to Mission B.

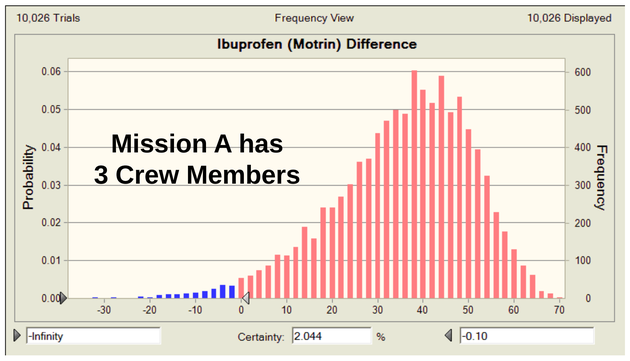


Example 2 – On a six month mission, is the amount of Ibuprofen sufficient if crew size is increased from three to six crew members?

The medical conditions that require Ibuprofen do not change due to crew size

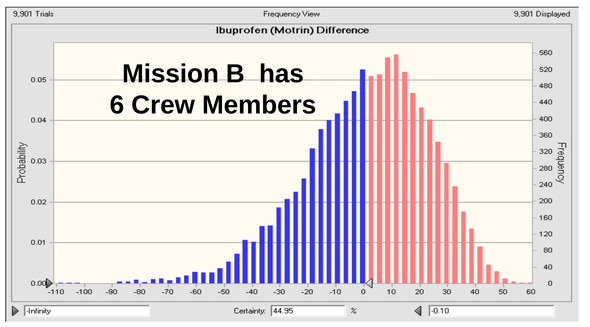
Most Frequent Medical Conditions requiring Ibuprofen

1) Back injury
2) Sprain/Strain - Shoulder
3) Paresthesia
4) Back pain (SAS)
5) Sprain/Strain – Elbow



Quantity of Ibuprofen is insufficient for 2.0% of the trials

Quantity of Ibuprofen is insufficient for 45.0% of the trials



Next Steps

- IMM Database Development
- Selection of long-term software technology platform
- External Verification & Validation; Non-Advocate Review (NAR)
- Configuration Management of Clinical Data Inputs
- ISS Medical System Re-design Support
- Constellation Program Health System Requirements Support